Plutonium Futures -- The Science Conference

Preface

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Plutonium is at once one of the most dreaded materials in the eyes of the public and the most fascinating of all elements scientifically. An artificial element discovered in 1941 by Glenn T. Seaborg and coworkers at the University of California, Berkeley, plutonium was immediately attractive as an atomic explosive during the Manhattan Project because of its large cross section. In fact, the special nuclear properties of ^{239}Pu make it a key ingredient of modern nuclear weapons and make it very attractive as a nuclear reactor fuel. Another isotope, ^{238}PU, is an excellent heat source for thermoelectric generators because of its copious radioactive alpha-particle decay.

With the end of the Cold War, the world faces a surplus of weapons-usable plutonium. Today, the challenge is to dispose of the surplus plutonium and prevent the proliferation of nuclear weapons. The United States is working closely with Russia is developing suitable disposal options. The United States is pursuing a dual-track approach of burning surplus plutonium as mixed oxide fuel or disposing it through vitrification and burial. A corollary challenge is to deal with the legacy of 50 years of nuclear materials and weapons production — that is, stabilizing production residues and scrap, disposing of radioactive wastes and cleaning up the production sites. Again, this will have to be accomplished while protecting the plutonium and ensuring the health and safety of workers and protecting the environment. Moreover, we face the challenge of how to manage the accumulating plutonium inventories being produced in nuclear power plants around the world. The industrialized nations of the world will have to weigh carefully the benefits of plutonium-containing nuclear fuels vs. the potential proliferation problems associated with reprocessing plutonium from spent fuel.

Clearly, many of these issues will require political solutions since public acceptance is such a strong driver in the democracies of the world. However, it is also time for the scientists and engineers to refocus their scientific attention to developing a better fundamental understanding of plutonium, its compounds and its interaction with humans and the environment. The special nuclear properties of plutonium are widely appreciated. Much less understood is the fact that plutonium also has a most unusual electronic structure. Specifically the close proximity of the 7s, 6d and 5f electrons in valence orbitals generates a strong competition among these configurations. In the solid state, plutonium sits on the edge between 5f electrons being localized (magnetic) or delocalized (bonding). Combined with the asymmetry of f-electron orbitals, this makes plutonium extremely sensitive to changes in temperature, pressure and chemical alloying — resulting in multiple allotropes and anisotropic structures and properties. Plutonium also has a great propensity for oxygen and hydrogen. The aqueous chemistry of plutonium is complicated by the existence of multiple oxidation states with similar reduction potentials and the strong tendency for the aqueous cations to complex with a wide variety of anions. Similarly, the chemistry of insoluble or immobile plutonium species in the environment is also complex -- sorption, hydrolysis, precipitation and complexation processes all play an important role. In addition, we find the combination of nuclear and electronic processes complicate the behavior even further. Nuclear induced self-irradiation effects in plutonium influence the properties of solid and liquid phases, with important implications to biological systems.

In these conference transactions we aim to enhance the dialog among scientists on the fundamental properties of plutonium and their technological consequences. Moreover, we hope that this conference will stimulate the next generation of scientists and students to study the fundamental properties of plutonium. We are encouraged by the great response we received to our call. The papers cover the entire spectrum of plutonium behavior. The contributors come from the scientific community across the world, with many excellent papers by authors from several countries. I am pleased that the Los Alamos National Laboratory was able to sponsor this conference in cooperation with t e American Nuclear Society. Our hope is that a renewed scientific interest in plutonium and the actinides can be generated, which in turn, will allow us to make great strides in solving the Cold War legacy problems and allow us to take full advantage of the benefits of the enormous energy potential of plutonium for the benefit of mankind.